ENERGY DISTRIBUTION IN THE VISIBLE SPECTRUM OF SUNLIGHT AND SKYLIGHT

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[U. S. Weather Bureau, Washington, March 24, 1925]

In the MONTHLY WEATHER REVIEW for October, 1924, **52**:476, Table 2 gives the relative intensity of sunlight, skylight, and the two combined, for different wave lengths in the visible spectrum. The data for sunlight were derived from Abbot's normal solar energy curve outside the earth's atmosphere (Weighted Mean Curve, 1920 and 1922),[1] in connection with atmospheric transmission coefficients for different wave lengths at Washington, D. C. and Mount Wilson, Calif.[2] The data for skylight have been derived from Priest's determinations of the color temperature of skylight,[3] and "Ratios of direct solar radiation received on a horizontal surface to diffuse sky radiation" given in Table 1 of this REVIEW for October, 1924, above quoted.

The present paper is confined to a consideration of sections (a), (b), and (c) of Table 2 of the above paper. It will be remembered that section (a) showed the conditions that prevailed at Washington on May 14, 1907, which was a typical summer day, with some haze in the atmosphere, but practically no clouds. Section (b) gave the conditions in the mean for the year on cloudless days in Washington, and section (c) the conditions that prevailed at Washington on February 15, 1907, which was a typical clear winter day.

The present note is in response to a request that the data designated "Total" in the sections of Table 2 be presented in a form convenient for determining the distribution in the visible spectrum of the energy received on a horizontal surface on typical cloudless days during the summer and fall months. June 21, September 21, and November 21 were decided upon for the dates of these typical days, and they were assumed to be in character similar to May 14, 1907, in Washington, to an average clear day in Washington, and to February 15, 1907, in Washington, respectively. The aim has been to show from the data given in Table 2 the changes in the energy distribution in the short-wave radiation received from hour to hour on a horizontal surface on the three selected dates.

For this purpose Figures 1, 2, and 3 have been prepared, in which the ordinates give relative intensities of radiation on an arbitrary scale. In all three figures a given value signifies the same intensity. The abscissas give the time in hours from apparent noon. The figures attached to each curve indicate the wave length of the radiation to which it applies, expressed in mμ.

To obtain the curves for Figure 1, (June 21 at latitude 41° N.), it was first necessary to construct auxiliary curves by plotting against solar altitudes the "Total" energy for the different wave lengths, as given in section (a) of Table 2,[4] with the sun at different zenith distances, or altitudes. This gave four points of the intensity curve for each wave length. Then from the curves drawn through these points the intensity corresponding to the sun's altitude at latitude 41° N. on June 21 was plotted for each hour from 6 a. m. or 6 p. m. to noon, apparent time.

The sun's altitude at the different hours was obtained by interpolation in Table 1, MONTHLY WEATHER REVIEW, November, 1919, **47**:771.

By a similar process the curves for Figures 2 and 3 were drawn. The process may be extended to any latitude in the eastern part of the United States where the atmospheric conditions do not differ materially from those at Washington.

As is well known, with decrease in the sun's altitude there is an increase in the proportion of the red and yellow rays in direct sunlight with respect to the blue or violet. Figures 1 to 3 show that this is not true with respect to the total daylight (direct sunlight plus diffuse skylight) received on a horizontal surface.

For example, at noon and at 6 p. m. on June 21, with the respective solar altitudes 73.4° and 14.9°, the ratios of the radiation intensity at wave length 397 mμ to that at 556 mμ are 0.57 and 0.82; at noon and 5 p. m. on September 21, with solar altitude 50.7° and 11.9°, they are 0.79 and 1.28; while at noon and 4 p. m. on November 21, with solar altitudes 30.1° and 8.1°, the ratios are 0.84 and 1.73, respectively.

The diurnal variation in the above ratios is due to the fact that while at noon the direct solar radiation received on a horizontal surface may be 6 to 8 times that received diffusely from the sky, which latter may be decidedly blue in color, the proportion is reduced to 1, or even less, as the sun approaches within a few degrees of the horizon.

There is also an annual variation in the blueness of the total daylight for any given altitude of the sun, due to the increased richness in short-wave radiation of both sunlight and skylight in the cooler months of the year. The bluer sunlight in the colder months is due to increased atmospheric transmissibility, which is more marked in the short-wave radiation than in the longer waves. The bluer skylight is due to a decrease both in the number and size of the dust particles and water droplets in the atmosphere.

[1] Abbot, C. G. and others. The distribution of energy in the spectra of the sun and stars. Smithsonian Miscellaneous Col., V. 74, No. 7, p. 15 and Figure 1.
[2] Annals of the Astrophysical Observatory, Smithsonian Institution, 3:135 and 138.
[3] Jour. Opt. Soc. Amer., 1920, 4: 483; 1923; 7: 38, 1184.
[4] Loc. cit.

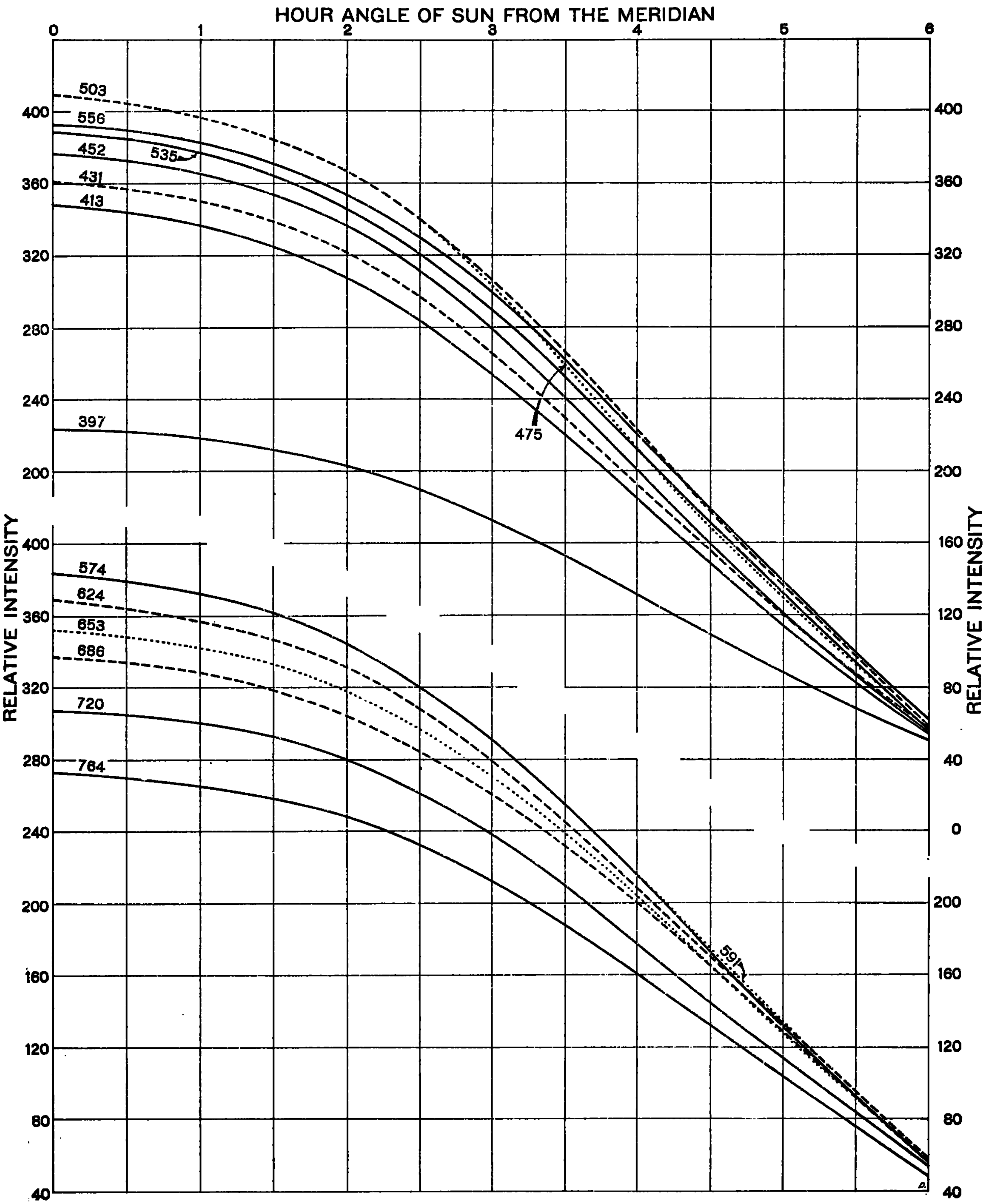

FIG. 1.—Energy distribution in daylight received on a horizontal surface at latitude 41° N. on June 21. Sky cloudless. (Wave lengths in m μ.)

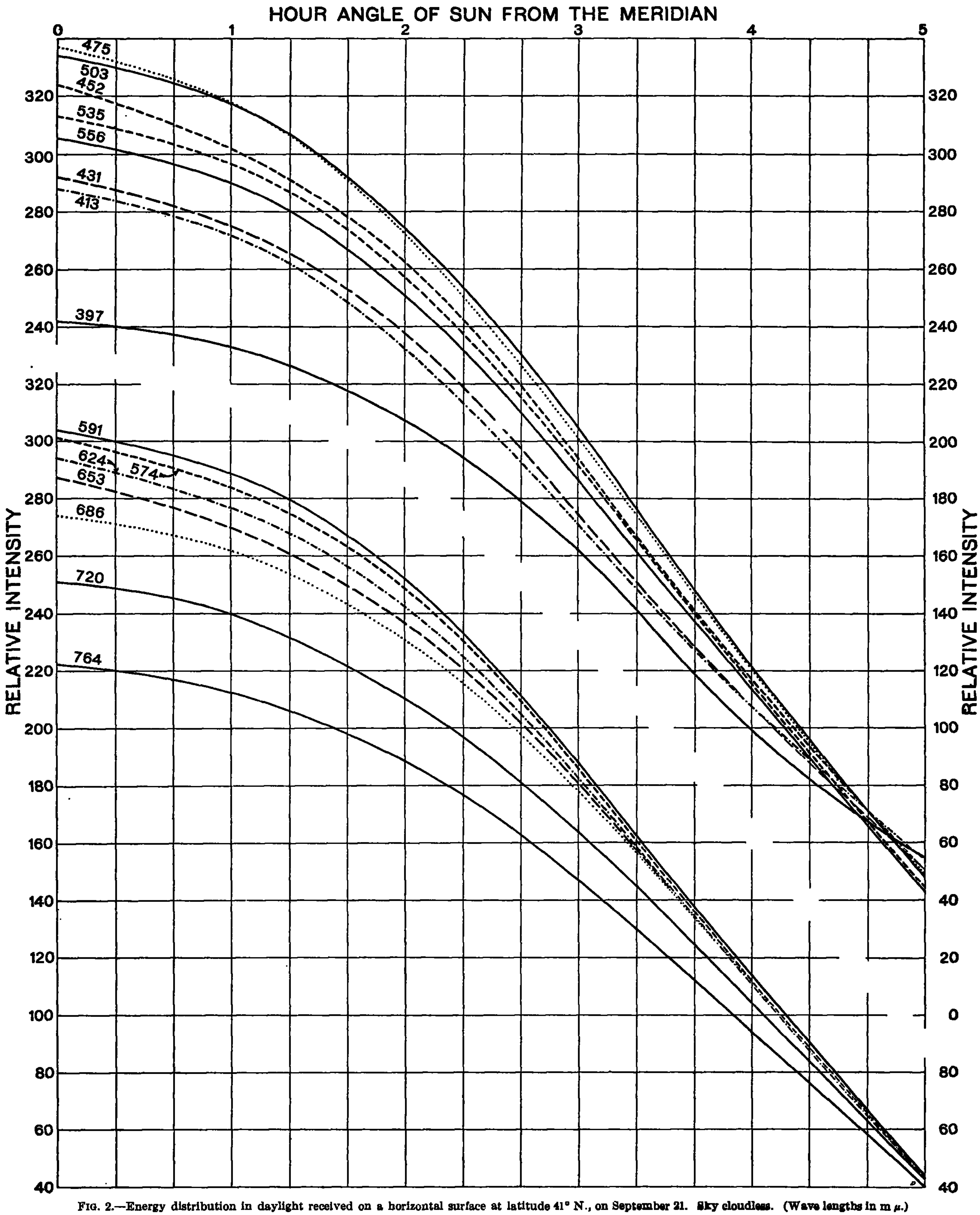

FIG. 2.—Energy distribution in daylight received on a horizontal surface at latitude 41° N., on September 21. Sky cloudless. (Wave lengths in m μ.)

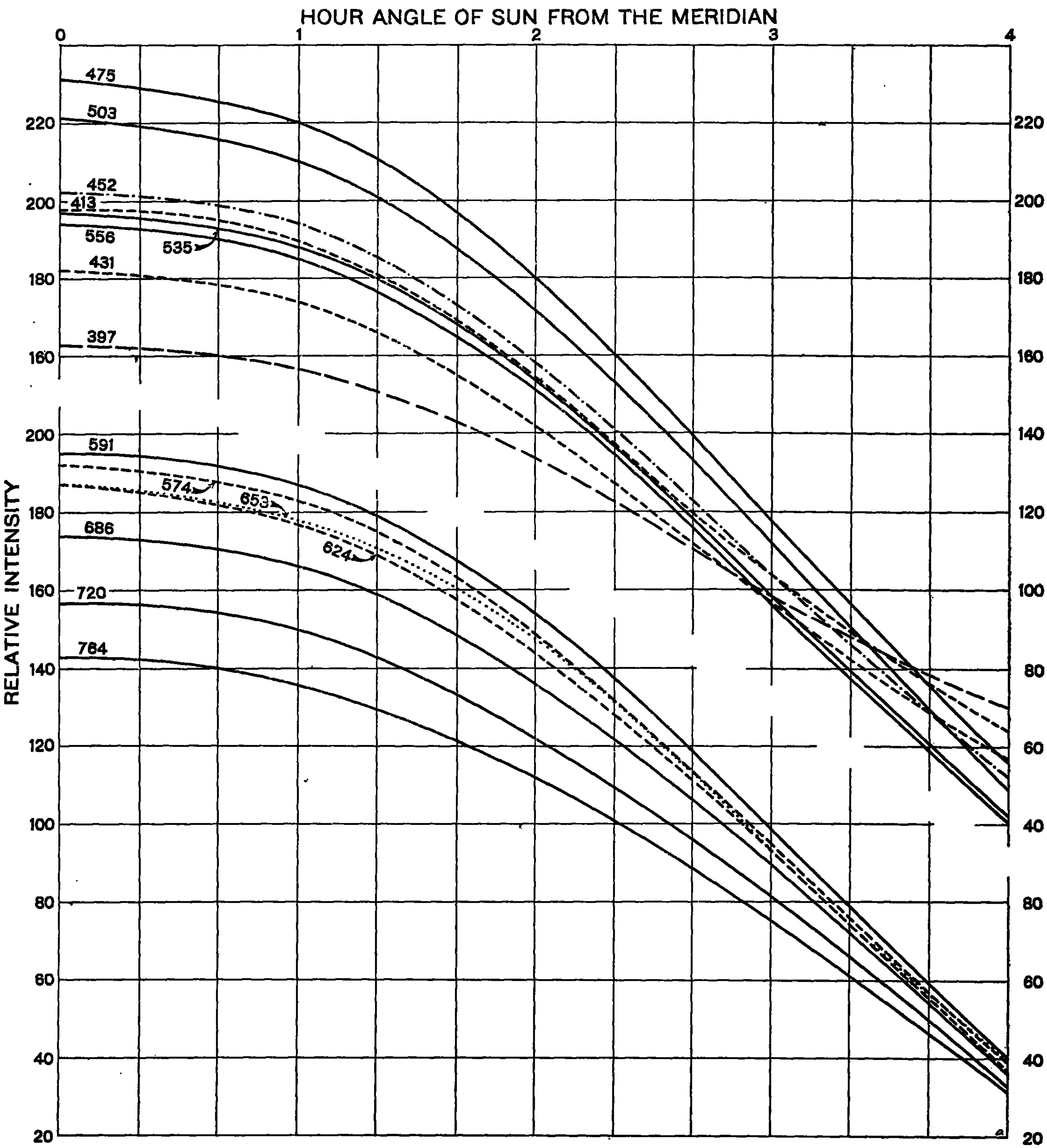

FIG. 3.—Energy distribution in daylight received on a horizontal surface at latitude 41° N. on November 21. Sky cloudless. (Wave lengths in m μ.)